



Prognostics Center of Excellence

NASA Ames Research Center

19. Nov. 2008

Prognostic Industry Day

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Edward Balaban

Prasun Bansal (Stanford intern)

Joe Camisa

Jose Celaya, Ph.D.

Navid Charoosheh (UMD/CALCE intern)

Matt Daigle, Ph.D.

Anish Kumar (DeAnza intern)

Scott Poll (ADAPT)

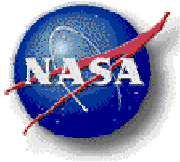
Bhaskar Saha, Ph.D.

Sankalita Saha, Ph.D.

Abhinav Saxena, Ph.D.

Mark Schwabacher, Ph.D.

Phil Wysocki

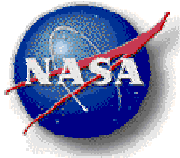


Agenda

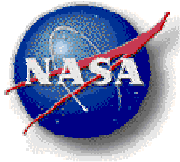
- 8.00AM-8.30AM Registration
- 8.30AM-9.00AM Welcome address (Gary Martin, Kai Goebel)
- 9.00AM-9.45AM Keynote address (Serdar Uckun)
- 9.45AM-10.15AM Talk on collaboration opportunities (Jaffer Hussain)
- 10.15AM-10.30AM IVHM project (Ashok Srivastava)
- 10.30AM-11.30AM Prognostic methodology (Kai Goebel)
- 11.30AM-1.00PM Lunch
- 12.00noon-1.00PM Prognostics demo (Bhaskar Saha)
- 1.00PM-3.00PM Interactive project demos/Poster session (Team)
- 3.00PM-3.30PM Q&A/Concluding remarks (Kai Goebel)
- 4.00PM-5.00PM Lab Tour (US Citizens only)
- 5.00PM-5.30PM Wind Tunnel Tour (by interest for US Citizens only) .



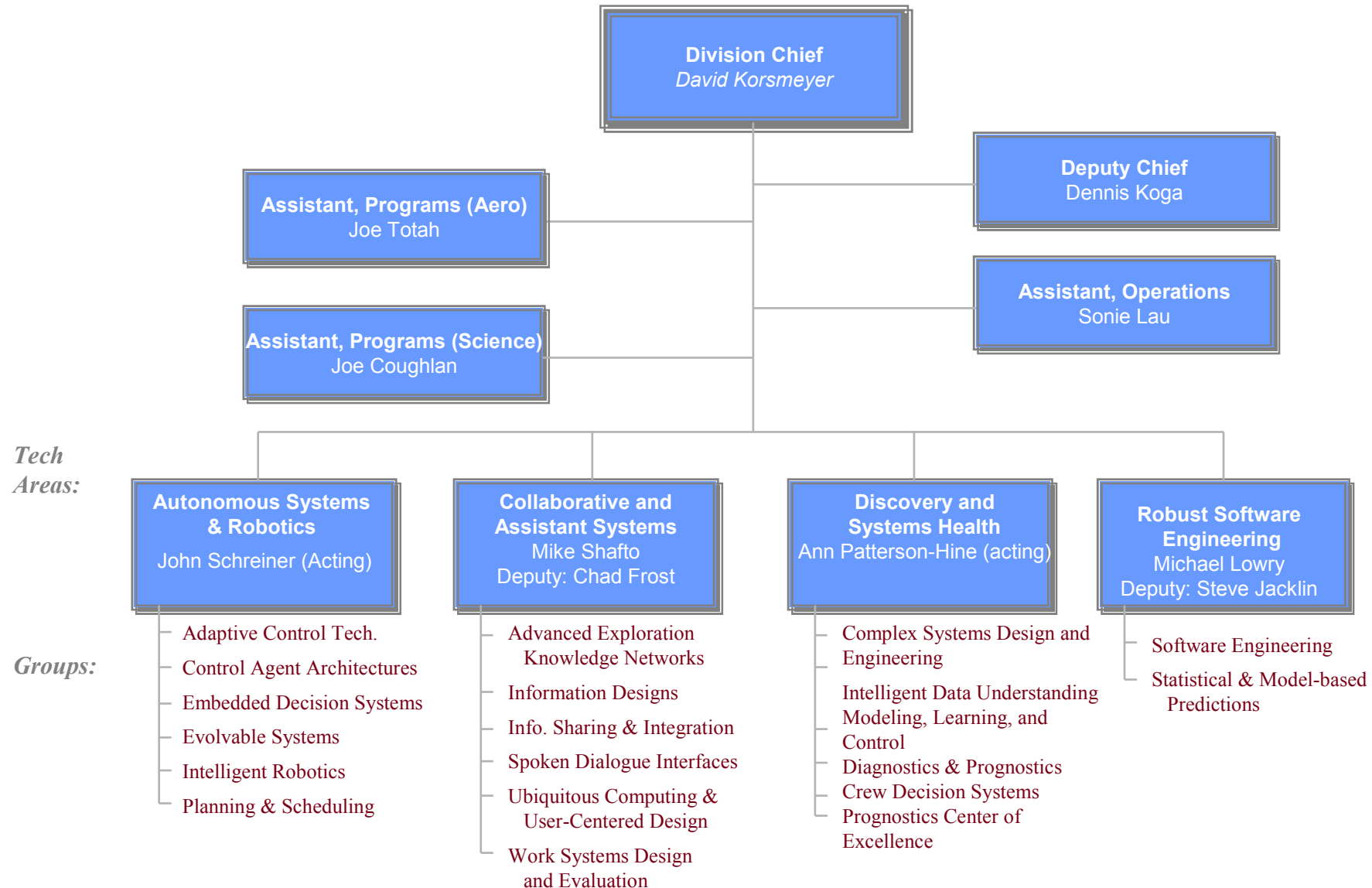
- Convey potential of prognostics in the engineered systems of today and the future
- Communicate NASA's resources available to develop system health management programs relevant to similar (or other) domains
- Allow identification of areas of potential interest
- Communicate processes for collaborations and interactions
- Seeking feedback: are we working on the right things?
- Coordinate research, learn from each other, avoid duplication, share results

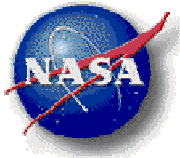


- **Prognostics Center of Excellence**



Intelligent Systems Division





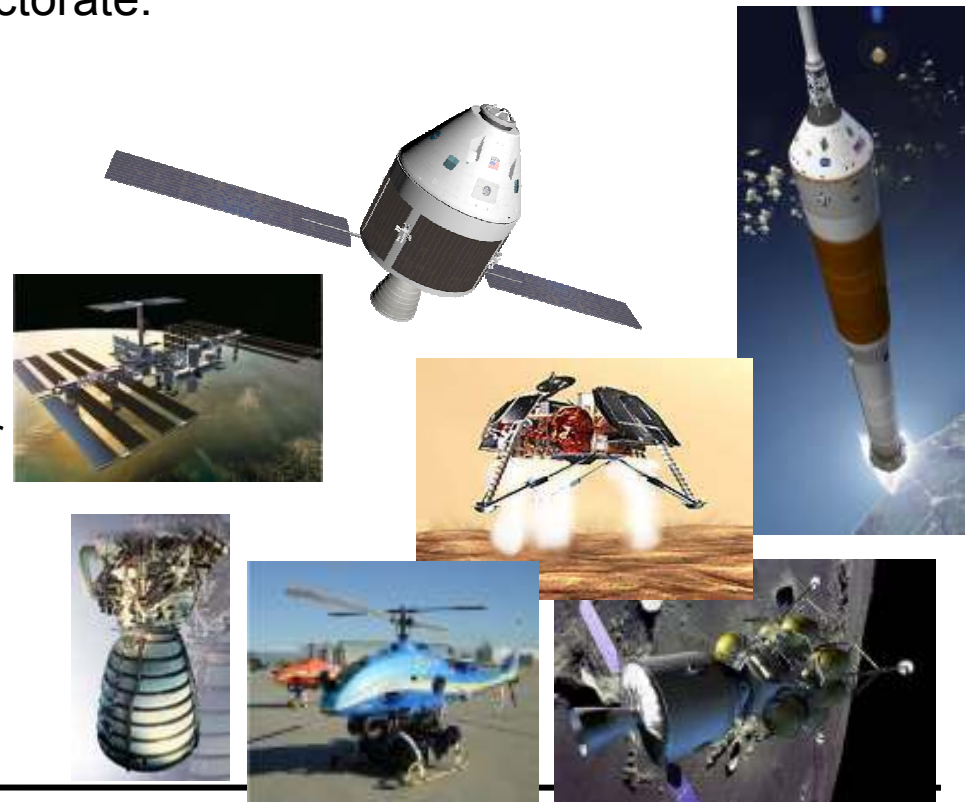
Discovery and Systems Health (DaSH)

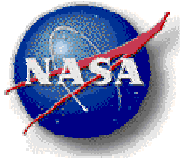
- Approximately 70 people in five groups
- Focusing on engineering and science data understanding
- The largest ISHM organization in NASA (nearly 60 engineers and researchers)
- Consolidates all ISHM activity at ARC
- Broad range of customers across NASA
- Mid-technology readiness level (TRL) technology development, maturation, and infusion



ISHM Activity in DaSH

- Aeronautics Research Mission Directorate:
 - Aviation Safety Program - IVHM; Aircraft Aging and Durability
 - Fundamental Aeronautics: Hypersonics and Subsonic-Rotary Wing
- Space Operations Mission Directorate:
 - ISS and STS support
- Exploration Science Mission Directorate:
 - ETDP - ISHM project
 - CEV ISHM work package
 - CLV ISHM work package
- Science Mission Directorate:
 - Intelligent Adaptive Systems
- Other:
 - NASA Engineering Safety Center
 - AFRL/Space Vehicles
 - Joint Strike Fighter



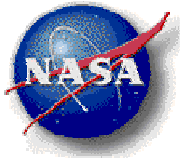


Prognostics Center of Excellence

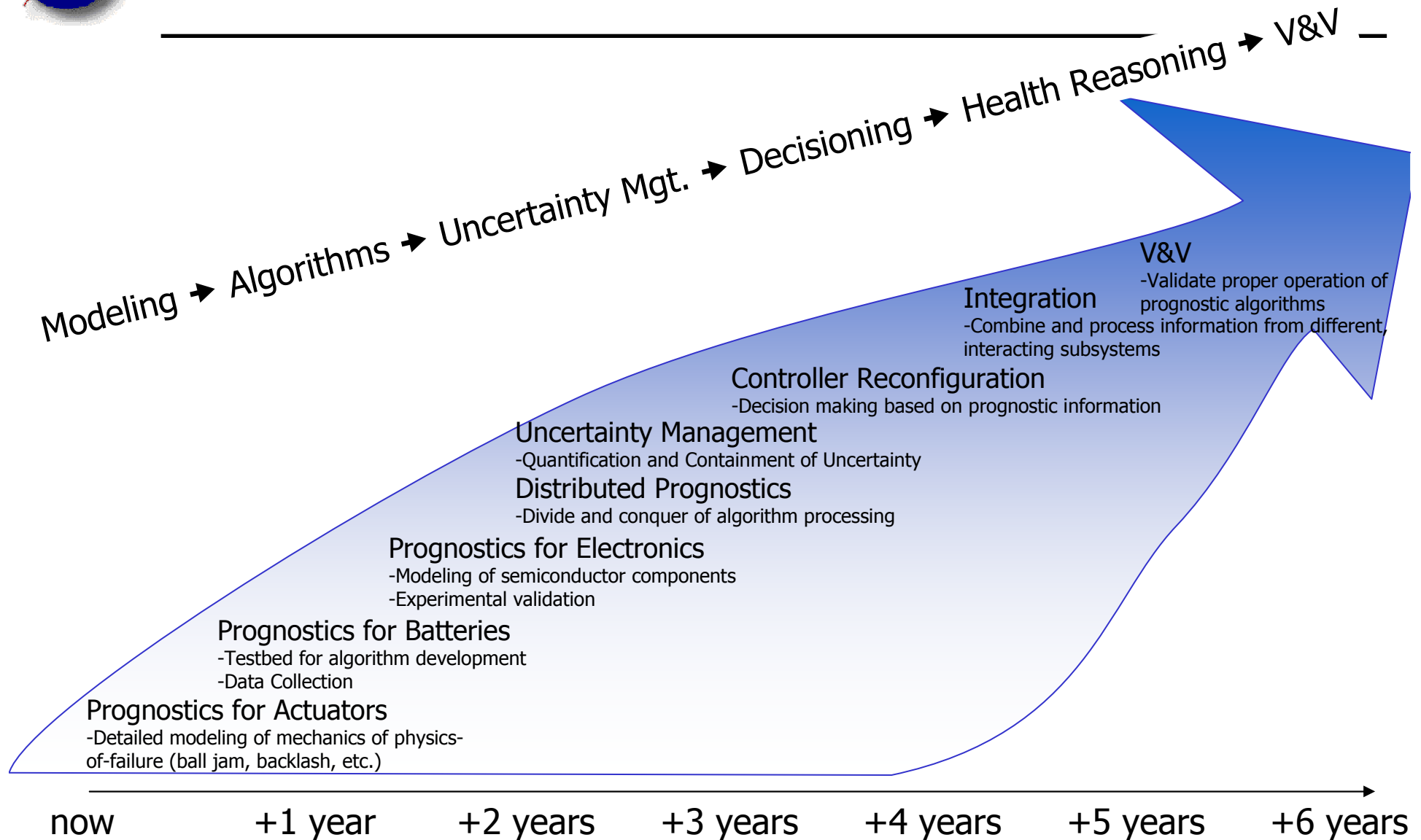
- Provides umbrella for prognostic technology development, specifically addressing technology gaps within the application areas of aeronautics and space exploration.
- En route to becoming a **national asset** with expertise in prediction technology and uncertainty management for the critical area of systems health management.
- Currently investigating damage propagation mechanisms on select safety-critical components
 - Actuators for transport-class aircraft
 - Electrical and electronic components in avionic equipment
 - Batteries
 - Composites
- Various testbeds that allow for data collection in a lab environment and a comparative analysis of different prognostic algorithms
 - data collected from aging processes is being made available to the research community.
- Common thread among the various avenues of prognostic technology development is the investigation of **physics-of-failure** at the component level.
 - Modeling damage initiation and propagation at this level is a key element in describing component health.
 - Just as important is algorithm development to provide the estimates for remaining component life and for uncertainty management.



- Establish and implement prognostics research plan for the next 10 years
 - Rigorous modeling of aging & damage propagation
 - Assessment of different fault modes
 - Capturing impact of environmental and operational influence on component aging
 - Discovery of early damage features
 - Determine sensors needed for optimal prognostics
 - Development of prediction algorithms that have high accuracy and precision customized for application domain
 - Methodical quantification and processing of uncertainty
 - Guide development of metrics for requirements definition and performance assessment
 - Drive Validation and Verification



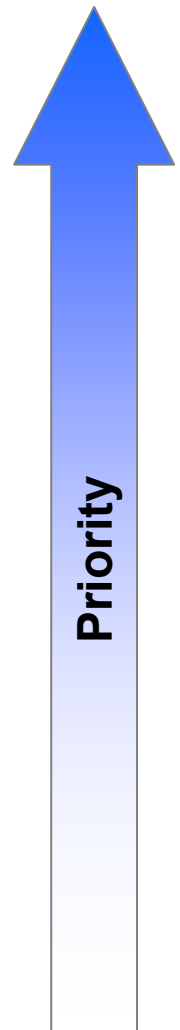
Roadmap

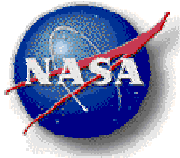




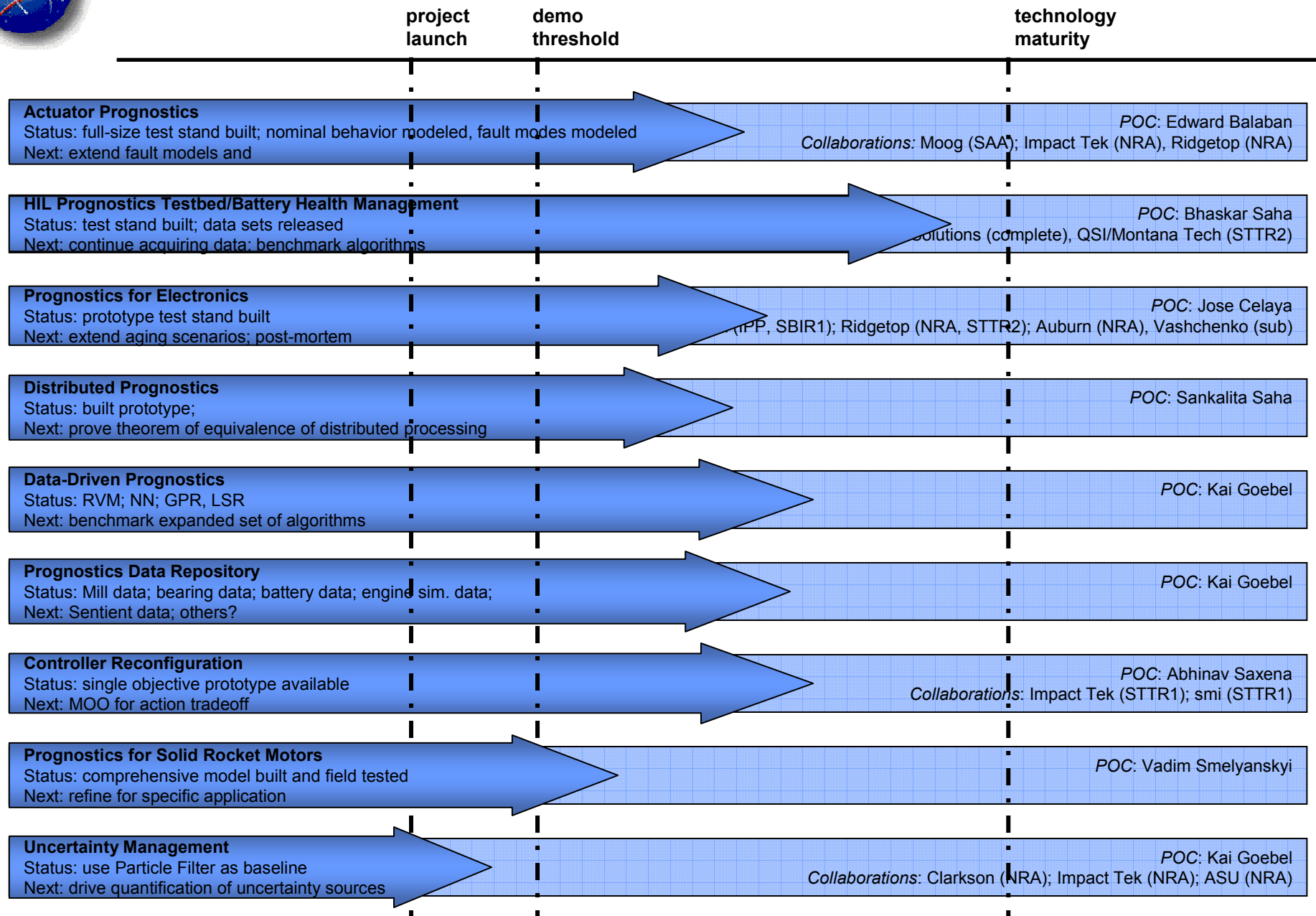
Research Outline

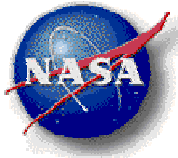
- Model Building
 - Understand the physics of failure and processes driving it
- Algorithm development
 - Derive remaining useful component life from reduced order models
- Uncertainty management
 - Capture and propagate information from multiple uncertainty sources
- Autonomic control reconfiguration
 - Translate local prognostic information into changes at the controller level such that controller objectives are satisfied in the long term
- Integration
 - Combine and process information from different, interacting subsystems
- Validation and verification of prognostic
 - Validate proper operation of prognostic algorithms
 - Challenge especially on new systems
- Post-prognostic reasoning
 - Turn information from prognostic reasoner into an action by considering
 - logistics information
 - mission information
 - fleet management information



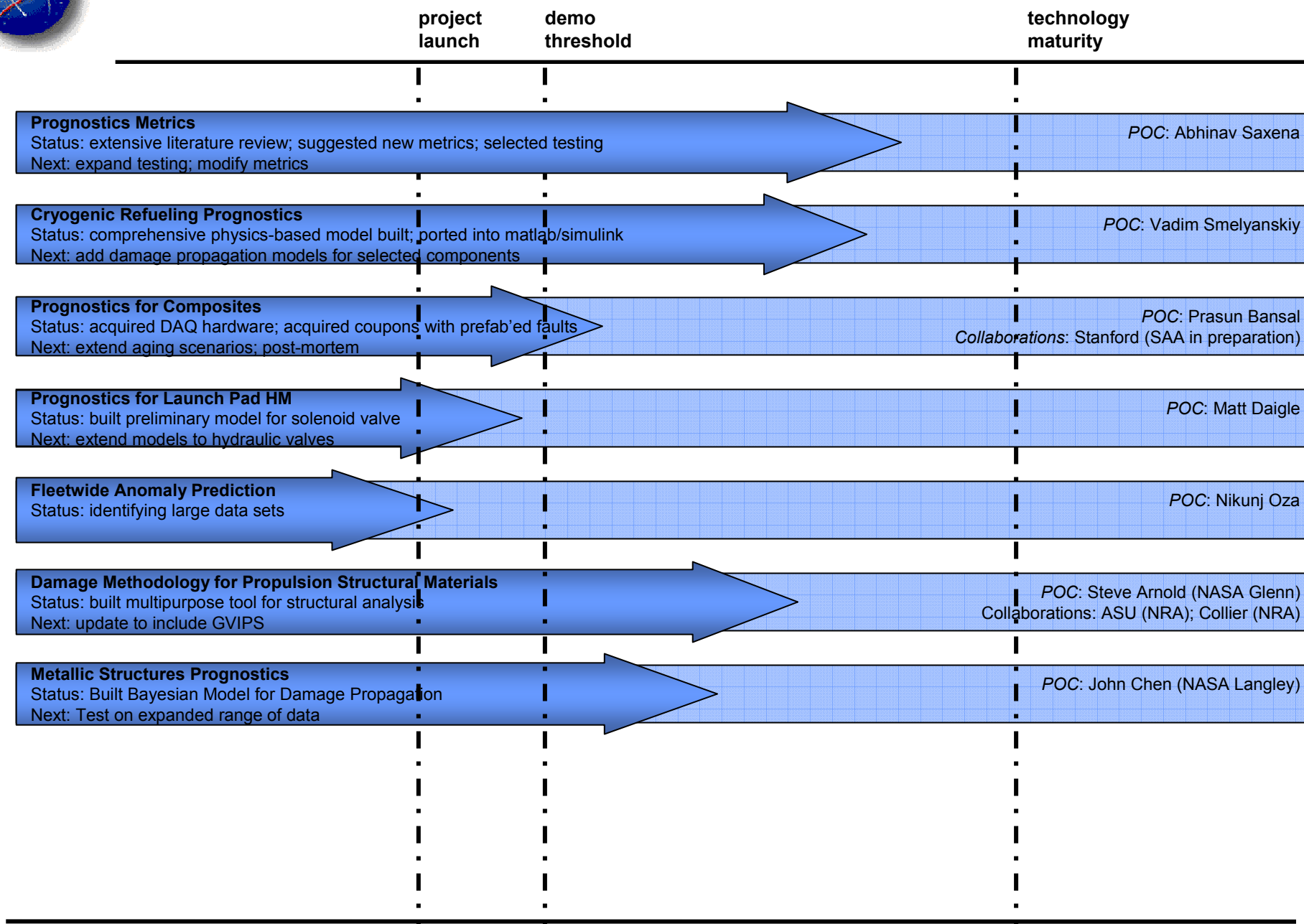


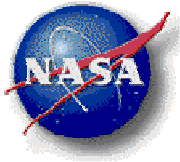
Projects & Collaborations



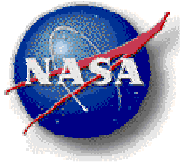


Projects & Collaborations

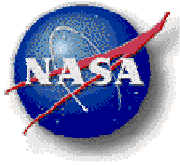




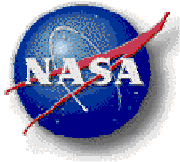
- Disseminating Knowledge
 - Published 38 papers in 2007 and 2008
 - Updated web sites
 - Prognostic data repository (data sets with combined >300 downloads)
- Engaging industry in SAA, NRA, SBIR, STTR, other
- Conferences
 - International Conference on Prognostics and Health Management
 - Technical Chair 2008
 - General Chair 2009
 - AAAI Fall Symposium on AI for Prognostics, Fall 2007
 - Organizer
- International Journal on PHM
 - www://ijphm.org
 - Associate Editors
- Accredited Standards Committee (ASC) and International Organization for Standardization (ISO)
 - Voting Member, Prognostics Working Committee
- Guest Lectures
 - UMD, Georgia Tech, UC



- Demos
 - Algorithm Testbed demonstrated via batteries
 - Actuator wing
 - Electronics
 - Aging testbed
 - Post-mortem analysis
 - Distributed Prognostics
 - Data-driven algorithms
 - Controller reconfiguration with prognostics
 - Composites structures
 - Cryogenic refueling
- Posters
 - Structures
 - Valves

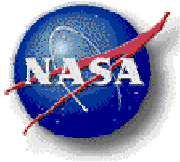


- Concluding Remarks



Feedback from Discussion Session

- Areas where NASA's participation is considered crucial
 - Technical Contributions
 - Spearheading Design for PHM/Prognostics
 - V&V for PHM/Prognostics
 - Comparing different approaches and reporting to community
 - Leadership role for PHM community
 - Setting standards and metrics
 - Educating the rest of the community on state-of-the-art in prognostics research
 - Help to coordinate information pushed in different organizations



Thank You

- Bhaskar Saha
 - Overall Organization
- Shirley Fauth
 - Coordination
- Jaffer Hussain
 - Business Development
- Ashok Srivastava
 - IVHM Support
- Ann Patterson-Hine
 - Logistics Assistance
- Elizabeth Foughty
 - On-site help
- PCoE Team
 - Countless hours of preparation